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Environmental Management in Dairy Production —

A Review of Capacity Building Material and Opportunities for Maziwa Zaidi in Tanzania



**Maziwa
Zaidi**



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Environmental Management in Dairy Production – A Review of Capacity Building Material and Opportunities for MaziwaZaidi in Tanzania

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1. Introduction

The dairy industry is one of the most important agricultural subsectors in Tanzania. The sector plays a great role in the economic and social lives of many households and it is perceived by many farmers as an important activity that contribute a significant supply of nutritious food, job employment, asset saving, soil fertility and income generation (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2019). The national dairy cattle herd includes the traditional sector that contributes 70% of the total milk produced, while the remaining amount is produced by smallholder dairy farmers with crossbreed and purebred Bos Taurus cows (Njombe et al. 2011).

The development of dairy sector is supported by the outstanding natural resources such as extensive rangelands and diverse natural vegetation that supports cattle feeding. Two thirds of the country's 88.6 million hectares are suitable for grazing. Despite these resources, the sector performs below its potential. The dairy industry has seen an increase in livestock numbers (4.3%) but only a small gain (1.8%) in productivity (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2019). The reason many smallholder dairy farmers experienced unsatisfactory production is due to erratic supply of dairy feed both in term quality and quantity, the presence of low yield breeds, and the lack of appropriate management practices (Mbwambo et al. 2017). The enormous growth in dairy farming in Tanzania has been facing a significant challenge in accessing quantity and quality fodder especially in the long dry season of the year to facilitate sustainable production of milk and meat, thus leading to animals being fed on undesirable feed stuffs hence lower milk production and animal productivity (Maleko et al., 2018).

To address key environmental challenges in dairy production, the Maziwa Zaidi program aims to catalyze uptake of “proven” dairy technology packages that improve the livelihoods of smallholder farmers. And this is done by improving sustainable environmental dairy production with the specific capacity building objective that aims to enhance national support for implementing effective and targeted capacity building to attract public and private sectors in development across the scale. It supports national plans to implement interventions that contribute to national food security by increasing dairy production, processing and marketing of dairy products to meet with national requirements while conserving the environment.

The overall objective of this report is to review existing capacity building themes and material on smallholder dairy and environmental management, and formulate recommendations and inform the way forward for capacity building within Maziwa Zaidi in 2021.



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2. Environmental issues around dairy production in Tanzania

Irrespective of the potential contribution of the dairy sector to the health, nutrition and income generation of smallholder producers in the country, dairy production is perceived as one of the main factors contributing to the environmental degradation. Significant adverse effects of dairy production on the environment may be categorized as follows:

Loss of vegetation cover and land degradation: This is ranked as important environmental problem in the country brought by continuous grazing or overgrazing, cut and carry of plant biomass for feeding animals without replenishing nutrients. This has been blamed to accelerate soil erosion and land degradation.

Greenhouse gas emissions contributing to climate change: The dairy cattle sector in Tanzania is estimated to emit about 28.8 million t CO₂eq annually. In this context, methane from enteric fermentation accounts for approximately 91.4% of total GHG emissions from dairy production. Emissions associated with the management of stored manure (CH₄ and N₂O) represent a further contribution of 2.3 million t CO₂eq. or 8.2% of total greenhouse gas emissions from the dairy cattle sector (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2019). Traditional livestock systems are responsible for the bulk of the emissions (97%) while improved dairy systems only contribute 3% to total emissions. At the national level, the emission intensity of milk produced in Tanzania is on average 19.9 kg CO₂eq./kg FPCM (fat and protein corrected milk). Average emissions ranged from 20.3 to 28.8 kg CO₂eq./kg FPCM for traditional systems, while in improved systems they ranged from 1.9 to 2.2 kg CO₂eq./kg FPCM. It has been reported that, in both systems, emissions intensity was lowest in temperate highlands and highest in the semi-arid zones (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2019). Thus, the bulk of emissions from on-farm dairy production is through enteric fermentation, manure deposition by grazing animals, manure management and application of manure to agricultural land. Feeding dairy animals with poor quality feeds results in low productivity and digestibility of feed and, as a result, high levels of emission intensities.

Water use and pollution: Improper storage management practices of animal manure can cause serious environmental problems. The run-off of animal wastes (slurry), constituting soluble nutrients in manure, may reach drainage channels, ditches and eventually flowing waters. The nitrogen, phosphorus and potassium content of the manure causes hypertrophication and leads to masses of algae (Nonga, 2011). These blooms can block out all the available light to the water and interfere with the decomposition process leading to a high biological oxygen demand (BOD) thereby causing depletion of oxygen in the water. This is detrimental to the living organisms e.g. fishes and aquatic plants at the area. Also, animal wastes contribute to the increase in suspended material in the water solution and together with decomposition of organic matter can cause the water body to have a strong unpleasant odour, taste and/or colour. In addition, dairy production is known for high use of drinking water which is a challenge for water resource constrained areas.

3. Capacity building for environmental management in smallholder dairy production

Improved environmental management practices, integrated in smallholder dairy keeping, can reduce the adverse impacts on the environment. Such opportunities for improved environmental management exist across various areas, and many different organizations have produced capacity building material to convey the necessary technical skills. All reviewed capacity building and training material is summarized and cited in Table 1, while Table 2 highlights interventions specifically for reduction of greenhouse emissions.

3.1 Sustainable soil management

Intensive dairy production can lead to soil and water pollution. Inappropriate use and management fertilizers (organic and inorganic), use of water, and manure disposal lead to high concentration of nitrogen, phosphorus and animal waste (Nonga, 2011, Kusiluka et al., 2012). These need validation of appropriate technologies including soil and water conservation, soil fertility management, agroforestry, water harvesting, conservation agriculture and promotion of indigenous knowledge for enhancing productivity and production (Majule and Shishrima, 2008). The technologies involved in enhancing soil management can be;

- Soil erosion control: Soil erosion is caused by wind, water or deep tillage, and leads to deterioration of the physical, chemical and biological properties of soils as well as loss of natural vegetation. Recommended practices to control erosion include the use of farmyard manure and agroforestry practices, improved fallow, mixed farming, minimum land tillage and growing of forage grasses especially on contours.
- Vegetation management: Improper cultivation practices, deforestation, overgrazing, fires and collection of wood for fuel and construction are the major causes of vegetation degradation in this region (Dallu, 2002). Destocking, confining dairy animals and restricting shifting agriculture, and tree planting promote natural regeneration of plants.

3.2 Animal health

The prevalence of various animal diseases, diseases transmitted by ticks, internal and external parasites affects the performance of dairy cattle. Animal health affects emission intensity through the “unproductive emissions” related to mortality and morbidity. Animal mortality rates are high, ranging between 15 percent and 25 percent for calves, regardless of the system. Many of the health problems result from poor animal condition as a consequence of inadequate nutrition, but also from the limited access to animal health services. Major animal diseases include East Cost Fever, contagious bovine pleuropneumonia (CBP), brucellosis, rinderpest, ticks and internal parasites. Sickness has an indirect effect on emission intensities through slow growth rate, reduced mature weight, reduced reproductive performance and decreased milk production (Kusiluka et al., 2012). Improving the reproduction rates and extending the reproductive life of the animal will increase productivity and reduce CH₄ and emission intensities. Relevant interventions include reducing the incidence of endemic, production-limiting diseases that have a number of negative outcomes, including death or cull of previously healthy animals, reduced live-weight gain, reduced milk yield and quality, reduced fertility, abortion and/or increased waste in the system. Healthier animals are generally more productive and have lower CH₄ emission intensities.

3.3 Improved animal genetics

About 97% of the cattle population in Tanzania are local breeds. While adapted to feed and water shortages, disease challenges, and harsh climates, the productivity of these breeds is generally low. Milk production is as low as 0.5 to 0.8 liters per cow per day over a lactation period of 200 days. Enhancing the genetic potential of the animal is critically important, but it is equally important not to promote high genetic potential animals into climates and management environments where high-producing animals can never achieve their potential and will, in fact, perform worse than native breeds or crossbreeds due to management, disease, or climatic challenges. Presence of large herds of cattle in many sub-Sahara countries are due to fulfilling multiple roles ranging from droughty power, to produce manure, milk and meat, with low level of nutrition supply that leads to low production. This creates high competition with other users of land and water resources and the environment. Hence, an acceptable, efficient and sustainable way of production like genetic selection and breeding needs to be applied in the production system for dairy and environment sustainability. Genetic selection is a key measure to increase productivity of animals. Breeding can help adapt animals to local conditions and address issues associated with reproduction, vulnerability to stress, adaptability to climate change, and disease incidence. Improved breeding management practices (using AI for example and ensuring access to wide genetic pools for selection) can accelerate those gains (FAO, 2014).

3.4 Improving feed and nutrition

Improving feed quality and quantity can be achieved through improved grassland management, improved forage and pasture species, forage mix and greater use of locally available supplements. Matching ruminant requirements with feed and forage resources, ration balancing, undertaking adequate feed preparation and forage conservation will improve nutrient uptake, ruminant productivity and fertility.



Figure 1: Dairy cows feeding on corn silage in Kilimanjaro region.
Credit: David Ngunga/Alliance



Figure 2: Improved forage species *Brachiaria* hybrid cv. Cobra in Tanga. Credit: David Ngunga/Alliance

Table I: Different training materials on environmental management in dairy production

Reference	Format	Target group	Content	Weblink
SNV (2013)	Manual	Technical staff like government and NGO extension officers	Impact of livestock on climate and mitigation strategies; detailed economic information	https://snv.org/cms/sites/default/files/explore/download/csa_training_manual_2013_snv_bhutan.pdf
CIAT & World Bank (2017)	Brochure	Livestock stakeholders, policy makers, researchers and civil society representatives	Greenhouse gas mitigation potentials in the livestock sector; economic information	https://ccafs.cgiar.org/resources/publications/climate-smart-agriculture-tanzania
Maleko et al. (2018)	Article	Livestock stakeholders, policy makers, researchers and civil society representatives	Adaptation and mitigation to climate change; adoption of improved feed production, conservation and utilization technologies and practices in dairy farming; promising economic & environmental gains with improved breeds and feeding strategies	https://repository.ruforum.org/system/tdf/Maleko%20et%20al%202018.pdf?file=1&type=node&id=37378&force=
FAO (2013)	Technical paper	Livestock stakeholders, policy makers, researchers and civil society representatives	Mitigation of greenhouse gas in livestock production; a review of technical options for non-CO2 emissions	http://www.fao.org/3/i3288e/i3288e.pdf
Tungaraza (2013)	Powerpoint slides	Livestock stakeholders, policy makers, researchers and civil society representatives	Dairy /livestock and the environment in Tanzania, GHG emissions, economic information	https://www.slideshare.net/ILRI/cleaned-project-tungarazasep2013
Teenstra et al. (2015)	Manual	Extension staff	Manure Management in the (Sub-)Tropics; Integrate manure management practices into livestock systems and improve existing practices to reduce SLCPs and other harmful emissions; economic cost/benefits	https://www.researchgate.net/publication/283637566_Manure_Management_in_the_Sub-Tropics_Training_Manual_for_Extension_Workers

Reference	Format	Target group	Content	Weblink
Baijukya et al. (no date)	Manual/ guideline	Livestock stakeholders, policy makers, researchers and civil society representatives	Land Degradation and Opportunities for Sustainable Management of Kagera River Basin-Tanzania; various reasons of land degradation and implications for livestock; mitigation options	http://www.fao.org/tempref/agl/agll/kageradocs/03methodologies_results/tz_findings_pra_transect.pdf
FAO (1999)	Manual	Livestock extension staff	Biogas technology; feeding practices to reducing GHG emissions; economic cost/benefits	https://sswm.info/sites/default/files/reference_attachments/FAO%201996%20Biogas%20Technology%20A%20Training%20Manual%20for%20Extension.pdf
Lukuyu et al. (2012)	Manual	Livestock extension staff and farmers	Feeding dairy cattle in East Africa; feeding practices to reducing GHG emissions; economic cost/benefits	https://cgspace.cgiar.org/bitstream/handle/10568/16873/EADDDairyManual.pdf
ILRI (2019)	Manual	Livestock extension staff and farmers	Climate change mitigation and adaptation; feeding practices to reducing GHG emissions	https://www.ilri.org/publications/training-manual-smallholder-dairy-producers

3.5 Manure management practices

Proper integrated manure management is currently not a common practice in most smallholding livestock production systems in Tanzania, leading to loss of its quality (nutrients), environmental degradation, human and livestock health risks and emissions of greenhouse gases. The challenges observed in management may be due to nonexistence of either appropriate place to dispose or appropriate technology to re-utilize animal dung and maintain environment regulations (Majule et al., 2014). Diet can have a significant impact on manure (feces and urine) chemistry and therefore on GHG emissions during storage and following land application. Nitrogen in animal manures is present in two forms: organic and (inorganic) ammoniacal nitrogen. Most organic N is contained in the organic matter, while the ammoniacal N is present as either ammonium (NH_4^+) or as free ammonia (NH_3). Exposed to open air, NH_4^+ is transformed into gaseous NH_3 that is usually lost into the atmosphere (FAO & New Zealand Agricultural Greenhouse Gas Research Centre, 2019). Decreased digestibility of dietary nutrients is expected to increase fermentable organic matter concentration in manure, which may increase manure CH_4 emissions. Feeding protein close to animal requirements, including varying dietary protein concentration with stage of lactation or growth, is recommended as an effective manure ammonia and N_2O emission mitigation practice. Low-protein diets for ruminants should be balanced for rumen-degradable protein so that microbial protein synthesis and fiber degradability are not impaired (CIAT, 2017).

Use of semi-permeable covers are valuable for reducing ammonia, CH_4 and odor emissions at storage, but are likely to increase N_2O emissions when effluents are spread on pasture or crops. Impermeable membranes, such as oil layers and sealed plastic covers, are effective in reducing gaseous emissions but are not very practical. Combusting accumulated CH_4 to produce electricity or heat is recommended. Acidification (in areas where soil acidity is not an issue) and cooling are further effective methods for reducing ammonia and CH_4 emissions from stored manure. Composting can

effectively reduce CH_4 but can have a variable effect on N_2O emissions and increases ammonia and total nitrogen losses. Anaerobic digesters are a recommended mitigation strategy for CH_4 generate renewable energy, and provide sanitation opportunities for developing countries, but their effect on N_2O emissions is unclear (Mushi et al., 2015).

Management of digestion systems is important to prevent them from becoming net emitters of GHG (FAO, 2010).



Figure 3: A heap of uncovered manure leading to emissions of methane, nitrous oxide gas and high nutrient loss. Credit: David Ngunga/Alliance



Figure 4: A heap of covered manure on a small dairy farm. Credit: David Ngunga/Alliance

Table 2: Summary of interventions that can be employed to support greenhouse gas emissions in dairy production.

Intervention	Objective and constraint addressed	Mode of action
Improved forage cultivation: establishment of forage grasses and legumes	Minimize quantitative and qualitative deficiency of basal diet to address feed seasonality and quality constraints	Improvements in digestibility lead to increased dry matter intake (DMI), energy availability, milk yields and decrease CH_4 emissions per unit of product.
Supplementation with leguminous fodder shrubs (<i>Calliandra</i> , <i>Leucaena</i> , etc.)	Minimize quantitative and qualitative deficiency of basal diet to address feed seasonality and quality constraints	Lower CH_4 observed with legumes is attributed to lower fiber content and faster rate of passage of feed through the rumen.
Supplementation of basal diets with high protein/energy concentrates	Supplementation of diet with good-quality concentrates helps overcome problem of palatability and digestibility	High-quality (more energy-dense or more digestible) diets provide more energy for production as a proportion of the gross energy intake (GEI) and dilutes the costs of maintenance than low-quality diets; therefore less CH_4 /FPCM is generated

Intervention	Objective and constraint addressed	Mode of action
Supplementation: Use of non-conventional feed resources e.g. sweet potato vines	Improve the quality of low basal diets and addresses feed availability during periods of scarcity	Promotes high dry matter intake and have a faster rate of passage through the rumen
Supplementation: Urea-treated crop residues	Improve the utilization of low quality roughages to address feed seasonality and quality constraints	Improving the nutritive value by increasing digestibility, palatability and crude protein content. The urea is converted to ammonia, which breaks down the fibrous material, making it accessible to the microbes.
Supplementation: Urea-molasses multi-nutrient blocks (UMMB)	Improve the utilization of low quality roughages	Satisfies the requirement of the rumen microorganisms by creating a better environment for the fermentation of fibrous material and increasing production of microbial protein. Reduces methane released by increasing the utilization of the diet.
Feed conservation (use of silage)	Improve the quality of low basal diets and addresses feed availability during periods of scarcity	Promotes high dry matter intake and have a faster rate of passage through the rumen.
Vaccination against East Coast Fever	Improve health status of animals, increase productivity and reduce economic losses for farmers.	Enhanced animal productivity and reduced CH ₄
Deworming (Helminthes control)	Improve health status of the herd by addressing internal parasites that affect efficiency. Addresses high morbidity, low milk production and milk wastage in dairy systems	Maximizes feed energy use by eliminating internal parasites, enhanced animal productivity and reducing emission intensity
Use of Artificial insemination (AI)	Improve production and reproductive traits. It addresses low productivity of local indigenous cattle.	Poor fertility causes livestock producers to maintain more animals per unit of production and keep more replacement animals to maintain the herd. When fertility is improved by using AI, the productivity of animals is improved and emissions reduced.

Source: FAO & New Zealand Agricultural Greenhouse Gas Research Centre (2019).

3.6 Use of biogas

Biogas provides a clean and easily controlled source of renewable energy and, when adequately applied, can significantly minimize the observed rate of deforestation in the country. Biogas has dual potential applications; it can either be used directly to replace firewood and charcoal and hence minimize the rate of deforestation or it can be converted to electricity using heat engine, solve electric energy challenges and used as best way in reducing emissions in air and soil. Slurry from manure stored in biodigesters for biogas emits less N_2O than fresh manure applied directly to grassland (Amon et al. 2006; Lekule and Sarwatt 1997). This occurs because during storage and anaerobic digestion, readily available carbon, which could be used to fuel denitrification, is incorporated into the microbial biomass or is lost as CO_2 or CH_4 . As a result, there is less available carbon in the slurry to fuel denitrification when the slurry is applied to land (Mushi et al. 2015). Indeed, controlled anaerobic digestion is potentially a “win–win” management of animal manure, since CH_4 emitted during storage (as a biogas) is used to produce heat and electricity, whereas N_2O emissions after digested slurry is spread are also reduced. The rate, timing, and placement of animal effluent applied to soils all affect potential N_2O emissions. Emission of N_2O from manure is higher when manure is applied to wet soil than when it is applied to drier soil; emission peaks generally occur within 24h of application (Mushi et al. 2015; Eckard et al. 2010).



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4. Conclusions and recommendations

The Maziwa Zaidi program and its partners, under the CGIAR Research Program on Livestock, aims at capacitating and disseminating sustainable dairy technology packages through agripreneurs to dairy groups and farmers. Further, the project aims at raising awareness of environmental management opportunities in dairy production among stakeholders such as NGOs, private sector and policy.

A variety of organizations have developed capacity building materials on environmental management in smallholder dairy systems, which are summarized and cited in Table 1. Main environmental impacts that are addressed in these materials include i) loss of vegetation cover and land degradation; ii) greenhouse gas emissions contributing to climate change; and iii) water use and pollution.

For the purpose of Maziwa Zaidi integration, mainstreaming environmental sustainability into integrated technology packages disseminated by agripreneurs, we recommend inclusion of the following themes in capacity building efforts: a) Sustainable soil management including erosion control and vegetation management; b) improved animal health measures reducing 'unproductive emissions'; c) improved animal genetics; d) improved feed and nutrition; e) proper manure management and storage; and f) use of biogas.

Improvements in these areas cannot only yield productivity and profitability increases, but are also synergetic with decreasing environmental impacts per unit output, improving resource use efficiency. Environmental management opportunities need to be presented and perceived as a co-benefit instead of an additional activity that might counter-act economic interests of smallholder dairy producers.



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